MALAYSIAN JOURNAL OF INNOVATION IN ENGINEERING AND APPLIED SOCIAL SCIENCE (MyJIEAS)
e-ISSN : 2811-3780
VOLUME 04, ISSUE 01

Analyze Structural Model Of Mining Risk Education For Agro-Tourism

Zahrah[1] & Mansurni Abadi[2]

[1]Faculty of Management, Departement of economic, Bumigora University, Jl. Ismail Marzuki No.22, Cilinaya, Kec. Cakranegara, Kota Mataram, Nusa Tenggara Bar. 83127, Indonesia
[2]Faculty of Information technology, Departement of ICT, University of the people (Online university), 595 E Colorado Blvd Suite 623, Pasadena, CA 91101, United States

Corresponding Author's Email: [1] Zahrah@bumigora.ac.id

Article History : Received 25092024; Revised 09102024; Accepted 25102024;

ABSTRACT – Amidst ecological crisis challenges on our planet, the interplay between education and environmental sustainability intensifies especially in the context of mining activity. In 2001, an international workshop by Save the Children in Sweden centered on developing resources and educational media for mining awareness initiatives. The workshop highlighted the potential of post-mining reclamation in Indonesia to support biodiversity and transform mining education into agro-eco-tourism. This research aims to develop a structural model for mining risk education using literature review methods and Interpretative Structural Modeling. The study identified key objectives: (1) leveraging cultural anthropology to drive social change and sustainable development in urban settings, (2) enhancing environmental awareness through education, and (3) establishing Environmental and Sustainability Education with a Driver Power (DP) of [8] and Dependence (D) of [3]. The main changes include (1) generating risk mitigation ideas and motivating others to adopt similar approaches, (2) advancing intelligent mining practices, and (3) promoting safe behaviors with DP [6] and D [3]. Essential indicators include emphasizing agro-eco-tourism education and habitats for endemic species with DP [5] and D [2]. A significant challenge identified is the need for more awareness and understanding of the importance of transitioning from mining to agro-eco-tourism with DP [5] and D [1]. The proposed action plan includes interactive learning to promote agro-eco-tourism, fostering critical and creative thinking skills, and encouraging tolerance for diverse perspectives and cultures with DP [10] and D [2]. The overall consistency of the components ranges from 98.40% to 100.00%.

KEYWORDS : Agro-eco-tourism; educational-pedagogical; environmental-sustainability education

1.0 INTRODUCTION

It is important to note that mining is essential for economic growth, as it creates jobs, improves infrastructure, and attracts foreign investment. Therefore, the existence of the mining sector has contributed greatly to economic development in several countries, including Indonesia. Mine management in areas designated for temporary land use must also plan for post-mining activities once the mining period ends. Therefore, mine planning should aim to achieve the optimal level of extraction while ensuring environmentally and socially sustainable post-mining land utilization (PMLU), considering future land use options [1]. According to Measham, post-mining transition is an increasingly important topic in research, policy, and practice due to the rising number of mine closures expected worldwide in the coming decades[2]. In social sciences, historical post-mining objects deserve special attention because they have high cognitive and didactic value [3]. Interplay between post mining and education currently and future is more important.

In 2001, Save the Children organized a workshop in Sweden on creating resources for mining awareness program education. Children in mining-affected communities must receive education about the risks in their area, as it takes decades to clean up post-mining sites [4]. The closure and reclamation of mining sites can be turned into economic activities, such as creating attractions for ecotourism through flora and fauna cultivation. This transformation depends on the designated utilization zone in the environmental impact analysis document and Feasibility Study. It's considered a positive step in transitioning from the mining sector to agro-eco-tourism, offering a sustainable alternative given the long process required to renew the natural resources utilized by the mining sector.

One example of such efforts has been carried out in Pakem District, Bondowoso Regency, namely the creation of nature tourism on former mining land. The people of Pakem District, Bondowoso Regency are aware of the importance of managing former mining land so that it is

expected to provide an impact on economic welfare for the surrounding community [5]. The utilization of land reclamation and post-mining by various companies varies, this use can be in the form of: the hole method for water treatment, freshwater cultivation and agro-eco-tourism, the utilization of reclamation and post-mining land as agricultural plains for flora and fauna such as cultivating laying hens, cattle, plants, and so on [6]. Therefore, embedding Chemistry Education into Environmental and Sustainability Education based on the Eco-Reflexive Approach is important and needed [7]. With the increasingly negative impacts of environmental pollution on life caused by mining operations, a new generation of entrepreneurs should be called upon to take on regional environmental protection and global ecological improvement. A process of entrepreneurial education impact in a conceptual model is worth building on the core factor of environmental sustainability [8].

The benefits of environmental education in mitigating post-mining degradation risks include fostering creativity and enthusiasm. Environmental Education (EE) involves interactive, hands-on learning that encourages creativity and critical thinking. The integrated EE curriculum enhances student engagement, extends learning beyond the classroom, and cultivates critical and creative thinking abilities. It inspires students to explore and make informed decisions about complex environmental issues, nurturing a new generation of well-informed consumers, professionals, and decision-makers [9]–[12].

Environmental education also cultivates tolerance and empathy by prompting students to explore diverse perspectives. It aligns with academic standards across various disciplines, reduces fear of nature, encourages healthy lifestyles, builds resilient communities, and promotes responsible actions for environmental improvement. It empowers students and educators, fostering active learning, responsible citizenship, and student leadership. This study aims to construct a comprehensive model for educational transformation from post-mining degradation to agro-eco-tourism, taking into account ecological, social, and economic considerations. The study aims to establish a structural model for the academic transition from post-mining degradation to agro-eco-tourism by incorporating the interplay between the ecological, social, and economic dimensions [13]–[15].

2.0 METHODOLOGY

The methodology used in this study is a collaboration between the literature study method and Interpretative Structural Modeling (ISM) in 2021-2023. The criteria for the elements are selected based on elements and sub-elements in the dimensions of ecology, economy and socio-cultural aspects. This is based on considerations of sustainability and spatial planning and alternatives that will consider their use including efforts to increase land use wisely. The ISM technique is a group learning process in which structural models are generated to capture the complexities of a system, through carefully designed patterns using graphics and sentences [16].

The ISM technique is intended for study by a system, but can also be used by a researcher. The ISM technique is concerned with the interpretation of a complete object, or system representation through the systematic and iterative application of graphical theory. ISM is a process that transforms vague and poorly explained mental models into visible and clearly defined system models that are useful for a variety of purposes [17]

ISM technique is a systematic analysis of a program so that it provides valuable value to society in meeting current and future needs. ISM methodology and techniques are divided into two parts, namely Hierarchical arrangement and sub-element classification. The basic principle is the identification of structures within a system that provide high benefit value in order to formulate the system effectively and for better decision making. The structure of a hierarchical system is needed to further explain the understanding of the subject being studied. The understanding and views of hierarchy vary, depending on how the concept is used. The term hierarchy comes from the Greek word hieros which means holy and arkho which means

rule. In the modern formulation, hierarchy is interpreted as a degree of level (ranking of level), and several subordinates to others, with the assumption of being in a regular structural form.

Determining the level of hierarchy has many approaches, where there are five criteria. The first is the bond strength within and between groups. The second criterion is the relative frequency of oscillations (shocks), where lower levels are shaken faster than those above. The third criterion is context, where higher levels operate at a slower time frame than larger spaces. The fourth criterion is coverage, meaning that higher levels cover lower levels. The fifth criterion is functional relationships, where higher levels have slow variables that affect fast variables at lower levels. The ISM technique has been used in several studies including agro-eco-tourism design and others [18].

The program being reviewed for its structural hierarchy is divided into elements, where each element is broken down into a number of sub-elements. Each element is divided into a number of sub-elements until it is deemed adequate [19].The ISM technique provides a basis for program analysis where the information produced is very useful in policy formulation and strategic planning. Based on our finding programs can be divided into nine elements, namely: (1) community sectors affected by the program, (2) program needs, (3) main program constraints, (4) changes possible in the program, (5) program objectives, (6) benchmarks for assessing each program objective, (7) activities needed for action planning, (8) activity measures to evaluate the results achieved by each activity, and (9) institutions involved in implementing the program. The ISM method is able to complete the development of the hierarchical structure of each element in the program for the present and the future. Referring to the concept, Mining Risk Education towards Agro Eco-Tourism is designed with five elements, namely: (1) objectives; (2) possible changes, (3) benchmarks for assessing objectives; (4) main constraints and (5) institutions involved. Three things produced by the ISM method include: (1) key elements, (2) hierarchical structure of elements, and (3) grouping of elements into four classification sectors. The four classifications are sector I or independent, sector II or linkage, sector III or dependent, and sector IV or autonomous.

Independent sector classification is an element that has a large driving force, and small dependence. Linkage sector classification is a sector that has an unstable relationship between variables and any change in the action of the variable will have an impact on other sub-elements. Feedback from its influence can increase the impact, so this sub-element must be studied carefully. Dependent sector classification is a sub-element that is not free. Autonomous sector classification is a sub-element that is not directly related to the system, has a slight relationship, but can have a stronger influence on achieving goals. The ISM technique procedure is divided into two parts, namely the arrangement of the hierarchy and the classification of sub-elements. The classification of sub-elements refers to the processed results of the Reachability Matrix (RM) that have met the transitivity rules so that the Driver-Power (DP) value and Dependence (D) value are obtained. The classification of sub-elements is classified into 4 sectors, namely:

1. Sector 1; weak driver-weak dependent variables (Autonomous), namely sub-elements with DP values DP ≤ 0,5 X and value D ≤ 0,5 X with X is the number of sub-elements. Sub-elements in this sector are generally not related to the system, and may have little relationship even though the relationship may be strong.
2. Sector 2; weak *driver-strongly* dependent variables (Dependent), namely sub-elements with a DP value < 0.5 X and a D value > 0.5 X. The sub-elements in this sector are non-independent subelements.
3. Sector 3; *strong-highly dependent driving variables* (Linkage), namely sub elements with a DP value > 0.5 X and a D value > 0.5 Every action on a sub-element will impact other sub-elements, and feedback effects can magnify the impact.
4. Sector 4: strong driver-weak dependent variables (Independent) are sub-elements with a DP value > 0.5 X and a D value < 0.5 X. The sub-elements in this sector are the remaining part of the system and are called independent variables

3.0 RESULT

3.1. Program Structure Analysis

Development is dynamic change, it cannot be done all at once, but gradually, felt by all communities, both local communities and immigrants for the whole society, and the final condition deserves to be better than the previous condition. In the process of restoring post-mining land, various methods are employed: physical/mechanical methods, chemical methods, and biological methods , created agro eco tourism is best option from 7 option based on research written by Bing-yuan and K. Li-xun [20], that we mention on table below

Table 1. Post-mined land use alternatives and their technical requirements

S/no	Type of Land-use	Examples of Land-use types	Technical Requirements
1	Forestry	Orchard, lumber production, woodland, shrubs, herbs, and native forestation	The terrain may possess a favorable slope, and the uppermost layer of soil is required. The minimum depth of top soil required for tree planting should be 0.3 meters, while the maximum depth of the plant pit should not exceed 1 meter. If the filler material contains dangerous substances, a separate layer is necessary. The filling material should compact and have a minimum thickness of 0.4 m.
2	Agricuture	Arable farmland, garden, pasture, nursery	Land grading and topsoil distribution. The minimum topsoil thickness required for planting food crops should be at least 0.5 m. Additionally, it is imperative that the humus layer measure no less than 0.2–0.3 meters in thickness. The filler material must be free of any toxic substances or components. The thickness of the isolation layer should be greater than 0.4 m. The hydraulic conditions must be optimal. The requirement for topsoil is that its soil mass density should not surpass 1.5 g/cm3. The clay-to-sand ratio is either 1:3 or 1:2. The porosity must exceed a minimum of 40%–50%. The concentration of soluble sodium sulfate and magnesium sulfate does not exceed 5%. The concentration of sodium oxide should not exceed 0.01%, and the pH value should be within the range of 6 to 8.
3	Conservation	Habitation for wildlife, water supply (surface and underground)	The land needs to be punned well, and native plant species introduced.
4	Construction	Residential, commercial (shopping center), industrial (factory), educational (construction of schools of any kind) and, block and brick molding, sustainable community	The land needs to be punned well, and the houses need anti-deformation measures.

5	Intensive Recreation	Sports field, sailing, swimming, fish pond and game	The land requires effective irrigation. A layer that is separate from others is necessary, and it must have a minimum thickness of 0.5 m. In addition, cement may be required to solidify the surface if deemed necessary.
6	Non-intensive Recreation	Park and open green space, museum or exhibition of mining innovations	The land needs to be punned well and harden the surface if necessary.
7	Lake or pool	Aquaculture, sailing, swimming, water supply	The shoreline's slope should not be excessively steep. The water's expanse should be limited. The water must meet the quality criteria set by the fisheries.

Therefore, the development referred to in Mining Risk Education towards effective Agro-Eco-Tourism is education that is deemed to be inadequate in terms of strength and design in accordance with the local Spatial Plan and Detailed Spatial Plan. Therefore, the program structure that supports the strategy needs to be designed with the use of ISM. This method has the ability to identify the boundaries of internal and external factors of the program being studied, thereby producing better structuring decision output, as well as summarizing the interrelated relationships between specific problems or issues.

Table 2. Contextual relationships between model elements

Element	Contextual Relationships
1. Obyectives of the program	E^i supporting roleg E^j
2. Possible changes	E^i result E^j
3. Benchmarks to judge each goal by	E^iinfluence on E^j
4. Main constraint	E^icause E^j
5. Action Plan	E^i supporting role E^j

ISM can provide excellent conditions for obtaining diversity and very complex different points of view. The system elements are presented in a graphical representation of each relationship and the hierarchical level allows identification of the relationship between ideas and the determining structure in this complex problem. Based on this conception, the following elements and sub-elements can be studied;

1. Elements of Objectives

Elements of objectives devided into 8 (eight) sub-elements, as follows : *1st sub-element,* Social change towards sustainable development; *2nd sub-element*, Achieve environmental social-economic balance; *3rd sub-element*, Educate pedagogical become citizens who care about the environment; *4th sub-element*, Educate in chemistry education becomes Environmental and Sustainability Education (ESE) using eco-reflexive; *5th sub-element*, Efforts to eliminate the negative impacts of minning activities; *6th sub-element*, Creating a biodiversity conservation forest model ; *7th sub-element*, Mining activities don't leave problem in the future; and *8th sub-element*, Provive economic benefits to local society. Assessment by the experts on the contextual relationships between goals sub-elements expressed by symbols V, A, X and O, has shown the respondent's perception matrix from

sub-elements to direct relationships between sub-elements exposed in Table 3. The matrix format is commonly referred as the Structural Self Interaction Matrix (SSIM). The contextual relationship of the goals sub-elements have a supportive roles. The matrix formation is called structural self interaction matrix (SSIM). The contextual relationship of the sub-elements of the goal plays a supportive role.

Table 3. Results of aggregation on contextual relationships between objective elements from Mine Risk Education to effective Agro-Eco-Tourism

No	E_2	E_3	E_4	E_5	E_6	E_7	E_8
E_1	V	X	V	V	V	V	V
E_2	-	A	A	A	A	A	A
E_3	-	-	X	V	V	V	V
E_4	-	-	-	V	V	V	V
E_5	-	-	-	-	A	A	A
E_6	-	-	-	-	-	V	V
E_7	-	-	-	-	-	-	A
E_8	-	-	-	-	-	-	-

After the SSIM is formed, it is then converted in binary matrices 1 and 0 into an initial reachability matrix as shown in Table 4.

Table 4 : The results of the aggregation of ISM VAXO reachibility processing on sub-elements of the objectives of Mine Risk Education towards effective Agro Eco-Tourism and need to be achieved

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8
E_1	1	1	1	1	1	1	1	1
E_2	0	1	0	0	0	0	0	0
E_3	1	1	1	1	1	1	1	1
E_4	**0**	1	1	1	1	1	1	1
E_5	0	1	0	0	1	0	0	0
E_6	0	1	0	0	1	1	1	1
E_7	0	1	0	0	1	0	1	0
E_8	0	1	0	0	1	0	1	1

In the advanced stage of the ISM method, revisions were made to SSIM with transitivity rules until the final reachability matrix shown in Table 5 was produced. From the final reachability matrix, the level of *Dependency* and *Driver Power* of the objective elements of Mine Risk Education towards effective Agro-Eco-Tourism can be determined.

Table 5 : The result of the aggregation of final matrix revision on the elements of the objectives to be achieved Mining Risk Education towards effective Agro Eco-Tourism

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	D
E_1	1	1	1	1	1	1	1	1	8
E_2	0	1	0	0	0	0	0	0	1
E_3	1	1	1	1	1	1	1	1	8
E_4	**1**	**1**	1	1	1	1	1	1	8
E_5	0	1	0	0	1	0	0	0	2
E_6	0	1	0	0	1	1	1	1	5
E_7	0	1	0	0	1	0	1	0	3
E_8	0	1	0	0	1	0	1	1	4
DP	3	8	3	3	7	4	6	5	

The consistency of expert opinion is 98.40 percent (> 80 percent) means that the results of expert opinion are considered good.The results of ISM processing on research objectives show that, *1st sub-element*, Social change towards sustainable development, including focus on **cultural anthropology** (E1); *3rd sub-element*, Educate pedagogical become citizens who care environment (E3); and *4rd sub-element*, Educate in chemistry education becomes Environmental and Sustainability Education (ESE) using eco-reflexive have the highest Driver Power (DP) and lowest Dependency (D). These 3 (three) objectives are the key objectives of the program objectives. (Figure 1). **Cultural anthropologists** study how people who share a common cultural system organize and shape the physical and social world around them, and are in turn shaped by those ideas, behaviors, and physical environments. Cultural anthropology is hallmarked by the concept of culture itself [21]. Therefore, the Dayak tribe deserves to be included in every development

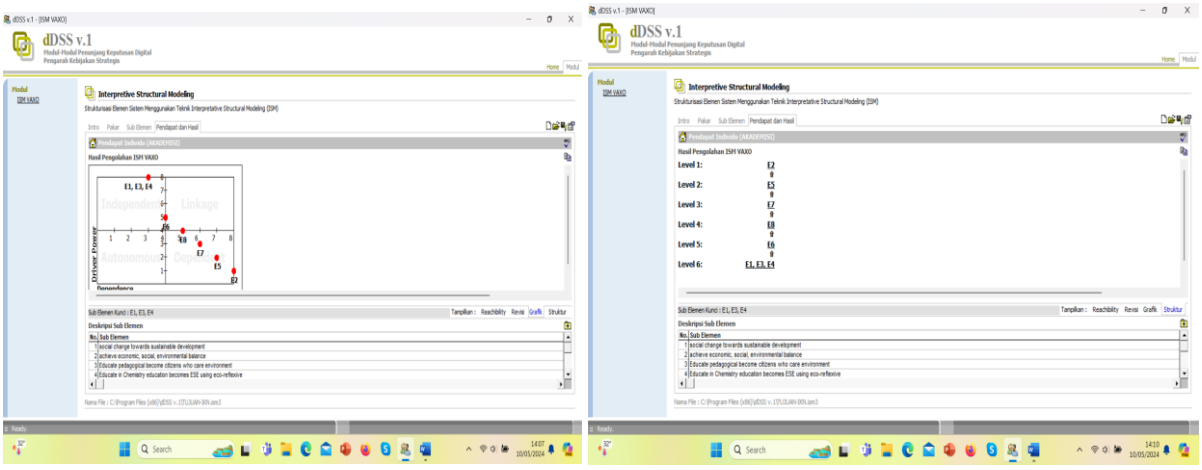

Figure 1. The relationship between DP (Driver Power) and D (Dependence) on the elements of the objectives to be achieved by the Mining Risk Education program towards Agro Eco-Tourism

Figure 1 also shows that *6th sub-element*, Mining activities don't leave problem in the future is included in the independent classification (E6) with DP [4] and D [5].The next ISM process shows that *the 2nd sub-element*, Achieve economic and social balance (E_2) with DP [1] and D [8]; *the 6th sub-element*, Creating a biodiversity conservation forest model (E_5) with DP [2] and D [7]; *the 7th sub-element*, Mining activities don't leave problem in the future (E_7) with DP [3]

and D [6]; and also *the 8th sub-element*, Provive economic benefits to local society (E_8) with DP [4] and D [5], are included in the dependent classification.

2. The Possible Changes Elements

The Possible Change Elements consist of 6 (six) sub-elements, namely: (1) Provides ideas to avoid danger & encourage others to do the same; (2) Intelligent minning ; (3) Data collection must play in the risk education efforts; (4) Changes in safe behaviour; (5) Social transformation; (6) Regulations are getting better; and (7) Educate to choose pro-environment job. The expert assessment on the contextual relationship between change sub-elements expressed by symbols V, A, X and O, obtained the respondent's perception matrix from the sub-elements to direct relationships between sub-elements listed in Table 6 of the SSIM. The contextual relationship of these changes results as shown on the next table :

Table 6 : The results of aggregation of contextual relationships between elements of change from Mining Risk Education to effective Agro-Eco-Tourism

	E_2	E_3	E_4	E_5	E_6	E_7
E_1	V	V	X	V	V	V
E_2	-	V	V	V	V	V
E_3	-	-	A	A	A	A
E_4	-	-	-	V	V	V
E_5	-	-	-	-	A	A
E_6	-	-	-	-	-	A
E_7	-	-	-	-	-	-

After the SSIM is formed, it is then converted in binary matrices 1 and 0 into an initial reachability matrix as shown in Table 7, below

Table 7 : Results of ISM VAXO processing aggregation reachibility sub-elements of changes in Mine Risk Education towards more effective Agro Eco-Tourism

	E_1	E_2	E_3	E_4	E_5	E_6	E_7
E_1	1	1	1	1	1	1	1
E_2	0	1	1	1	1	1	1
E_3	0	0	1	0	0	0	0
E_4	1	1	1	1	1	1	1
E_5	0	0	1	0	1	0	0
E_6	0	0	1	0	1	1	0
E_7	0	0	1	0	1	1	1

Furthermore, revisions were made to SSIM with transitivity rules until a final reachability matrix was produced to determine the DP and D levels of changes in Mining Risk Education towards effective Agro-Eco-Tourism (as shown on Table 8).

Table 8 : The aggregation results on the final matrix revision of the **changes** to be achieved through Mining Risk Education towards effective Agro-Eco-Tourism

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	**D**
E_1	1	1	1	1	1	1	1	7
E_2	1	1	1	1	1	1	1	7
E_3	0	0	1	0	0	0	0	1
E_4	1	1	1	1	1	1	1	7

E_5	0	0	1	0	1	0	0	2
E_6	0	0	1	0	1	1	0	3
E_7	0	0	1	0	1	1	1	4
DP	3	3	7	3	6	5	4	

The consistency of expert opinion is 97.96 percent (> 80 percent) means that the results of expert opinion are considered good.

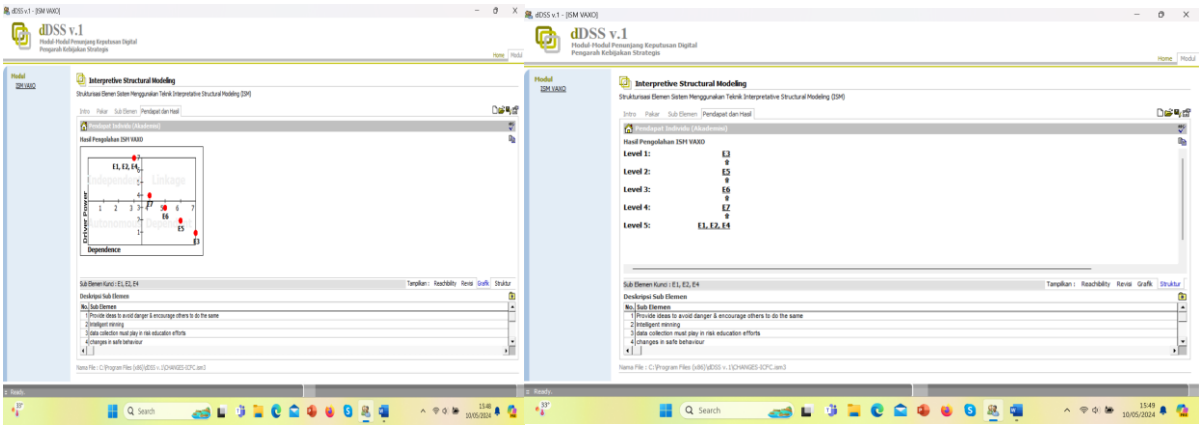

Figure 2 : The Relationship of Driver Power and Dependence on the **changes** to be achieved by the Mining Risk Education program towards Agro-Eco-Tourism

The results of ISM processing show that, *The 1st sub-element*, Provides ideas to avoid danger &; encourage others to do the same (E1); *The 2nd sub-element*, Intelligent minning [22](E2); and *The 4th sub-element*, Changes in safe behaviour (E4) have the highest DP (Driver Power) [7] and the lowest D (Dependence) [3]. The 3 (three) changes are key changes (Figure 2). Figure 2 also shown that *the 7th sub-element*, Educate to chose pro-environment job is included on the linkage classification (E_7) with DP [4] and D [4]. Furthermore, *the 6th sub-element*, Regulations are getting better (E_6) with DP [3] and D [5]l *the 5th sub-element*, Social transformation (E_5) with DP [7] and D [6]; and *the 3rd sub-element*, Data collection must play in risk education efforts (E_3) with DP [1] and D [7] are included on the Dependent sector.

3.2. **Objective Benchmark Element**

The objective benchmark element consists of 5 (five) sub-elements, namely: (1) Increased access to eco-tourism education services; (2) Quality of eco-tourism education; (3) Relevance of eco-tourism education; (4) Biodiversity index; and (5) Availability of habitat (natural or artificial) of endemic flora or fauna. From the expert assessment of contextual relationships between benchmark sub-elements which expressed by symbols V, A, X and O, obtained a matrix of respondents' perception from sub-elements to direct relationships between sub-elements exposed in table 9 of the SSIM. The contextual relationship of the goal benchmark plays an influencing role.

Table 9. Results of aggregation of contextual relationships between objectives benchmark from Mining Risk Education towards effective Agro-Eco-Tourism

No	E_2	E_3	E_4	E_5
E_1	V	A	A	A
E_2	-	A	A	A
E_3	-	-	V	X
E_4	-	-	-	A
E_5	-	-	-	-

After the SSIM is formed, then converted in binary matrices 1 and 0 into an initial reachability matrix as shown in Table 10.

Table 10. Results of The Aggregation of ISM VAXO reachibility processing sub-elements of objectives benchmark of Mine Risk Education towards more Effective Agro Eco-Tourism

	E_1	E_2	E_3	E_4	E_5
E_1	1	1	0	0	0
E_2	0	1	0	0	0
E_3	1	1	1	1	1
E_4	1	1	0	1	0
E_5	1	1	1	1	1

Furthermore, revisions were made to SSIM with transitivity rules until a final reachability matrix was produced to determine the DP and D levels of the benchmark objectives of Mining Risk Education towards effective Agro-Eco-Tourism (Table 10).

Table 11. Result of The Aggregation of The Final Matrix Revision from The Objective Benchmark to be Achieved by The Mining Risk Education towards Effective Agro Eco-Tourism

	E_1	E_2	E_3	E_4	E_5	D
E_1	1	1	0	0	0	2
E_2	0	1	0	0	0	1
E_3	1	1	1	1	1	5
E_4	1	1	0	1	0	3
E_5	1	1	1	1	1	5
DP	4	5	2	3	2	

The consistency of expert opinion by 100 percent (> 80 percent) means that the results of expert opinion are considered good.

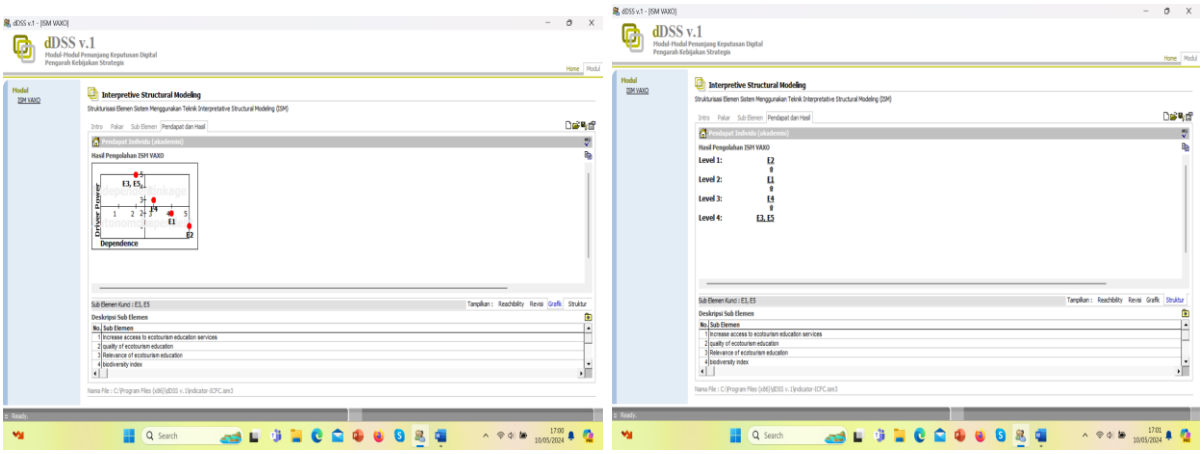

Figure 3. The Relationship between Driver Power and Dependence on the Objective Benchmark to be achieved by The Program of Mining Risk Education towards Agro Eco-Tourism.

The result of ISM Processing has shown that *3rd sub-element*, Relevance of ecotourism education (E_3); and *5th sub-element*, Availability of habitat (natural or artificial) of endemic flora or fauna [23][24] (E_5) have the highest DP [5] and lowest dependence D [2]. These 2 (two) objectives benchmark are the key benchmark (Figure 3). Figure 3 also shown that *the 4th sub-element*, Biodiversity index is included in the linkage classification (E_4) with DP [3] and D [3].Furthermore, *1st sub-element*, Increased access to ecotourism education services (E_1) with DP [2] and D [4], and *2nd sub-element*, Quality of ecotourism education (E_2) with DP [1] and D [5] are included in dependent sector.

3.3. Main Constraint Element

The main elements of constraints consist of 5 (five) sub-elements, namely: (1) Lack of awareness and understanding of post minning risk; (2) changes in culture and life style; (3) lack of resources and infrastructure; (4) regulatory and policy barriers; and (5) lack of supportsfrom government and company. From the Expert assessment of contextual relationships between constraint sub-elements expressed by symbols V, A, X and O, obtained the respondent's perception matrix from sub-elements to direct relationships between sub-elements as shown on table 11 of the SSIM. The contextual relationships of main constraint plays a causes role.

Table 12. The results of the aggregation of ISM VAXO reachibility processing are sub-elements of the main constraint Mining Risk Education towards more effective Agro-Eco-Tourism

	E_2	**E_3**	**E_4**	**E_5**
E_1	V	V	V	V
E_2		A	A	A
E_3			V	V
E_4				V
E_5				

After the SSIM is formed, then converted in binary matrices 1 and 0 into an initial reachability matrix as shown in Table 12.

Table 13 The results of the aggregation of ISM VAXO reachibility processing are sub-elements of the main constraint Mining Risk Education towards more effective Agro-Eco-Tourism.

	E_1	E_2	E_3	E_4	E_5
E_1	1	1	1	1	1
E_2	0	1	0	0	0
E_3	0	1	1	1	1
E_4	0	1	0	1	1
E_5	0	1	0	0	1

Furthermore, revisions were made to SSIM with transitivity rules until a final reachability matrix was produced to determine the DP and D levels of the main constraints of Mining Risk Education towards effective Agro-Eco-Tourism (Table 14).

Table 14. The results of the aggregation of the final matrix revision of the main constraints to be achieved Mining Risk Education towards effective Agro-Eco-Tourism.

		E_1	E_2	E_3	E_4	E_5	D
E_1		1	1	1	1	1	5
E_2		0	1	0	0	0	1
E_3		0	1	1	1	1	4
E_4		0	1	0	1	1	3
E_5		0	1	0	0	1	2
DP		1	5	2	3	4	

The consistency of the expert opinion by 100 percent (> 80 percent) means that the results of expert opinion are considered good

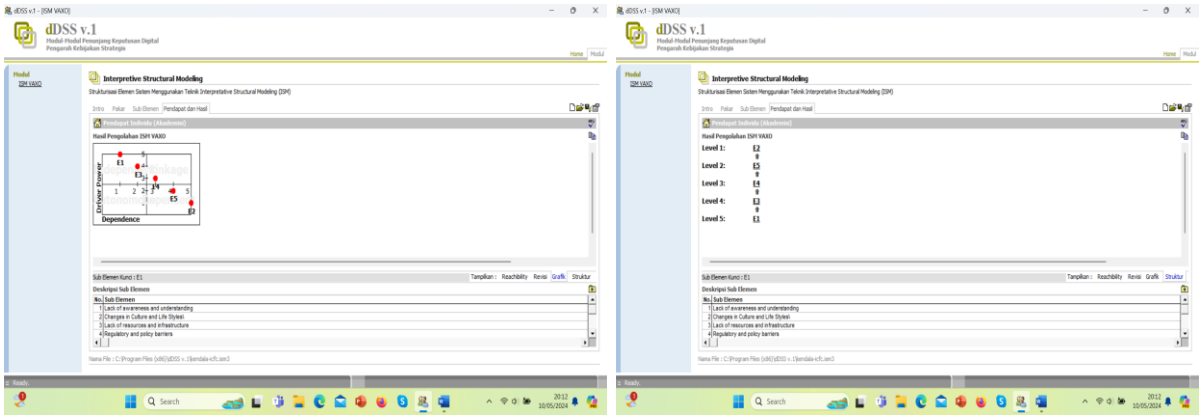

Figure 4. The Relationship of Driver Power and Dependence on the main constraints of Mining Risk Education towards Agro Eco-Tourism

The results of ISM processing has shown that, *the 1st sub-element*, Lack of awareness and understanding of post minning risk [25][26][27][28][29].(E1) have the highest DP [5] and the lowest D (dependence) [1], and it is called the key main constraint (Figure 4). While *the 3rd sub-element*, lack of resources and infrastructure (E3) is the main constraint which is in the independent classification with DP [4] and D [2]. Figure 4 also shown that *the 4th sub-element*, the regulatory and policy barriers are included on the Linkage Classification (E_4) with DP [3]

and D [3]. Furthermore, *the 5th sub-element*, Lack of supports from government and company (E_5) with DP [2,5] and D [4], and also *the 2nd sub-element*, Changes in culture and life style (E_2) with DP [1] and D [5] are included in the dependent sector.

3.4.Action Plan Element

The elements of the Action Plan consist of 11 (eleven) sub-elements, namely: (1) Interactive learning that sparks ecotourism, imagination & creativity; (2) Learning transcends the classroom on inter-connectedness of ecological, social & economy; (3) Developing & enhancing critical & creative thingking skills; (4) Promoting tolorance of different points of view &; culture; (5) Intergrates science & interdisciplinary learning; (6) Fosters sensitivity, appreciation & respect for the environment; (7) Healthy life style; (8) Strengthening Community, (9) Provides with support through grants & others resources; (10) Incorporating environtment education into curriculum; and (11) Education to get a job that does not damage the environment.

From the expert assessment of contextual relationships between constraint sub-elements expressed by symbols V, A, X and O, we obtained the respondents' perception matrix from sub-elements to direct relationships between sub-elements listed in Table 14 in SSIM. The contextual relationship of role constraints affects the success of Mining Risk Education towards effective Agro-Eco-Tourism, we explain in table

Tabel 15. Results of aggregation of ISM VAXO reachibility processing sub-elements of the action plan Mine Risk Education towards more effective Agro Eco-Tourism

No	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}
E_1	V	X	V	V	V	V	V	V	V
E_2	-	A	A	A	A	A	A	A	A
E_3	-	-	V	V	V	V	V	V	V
E_4	-	-	-	V	V	V	V	V	V
E_5	-	-	-	-	A	A	A	A	A
E_6	-	-	-	-	-	V	V	V	V
E_7	-	-	-	-	-	-	A	A	A
E_8	-	-	-	-	-	-	-	V	V
E_9	-	-	-	-	-	-	-	-	A
E_{10}	-	-	-	-	-	-	-	-	-

After the SSIM is formed, it is then converted in binary matrices 1 and 0 into an initial reachability matrix as shown in Table 16, below

Table 16. Results of aggregation of ISM VAXO reachibility processing sub-elements of the action plan Mine Risk Education towards more effective Agro Eco-Tourism

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}
E_1	1	1	1	1	1	1	1	1	1	1
E_2	0	1	0	0	0	0	0	0	0	0
E_3	1	1	1	1	1	1	1	1	1	1
E_4	**0**	1	1	1	1	1	1	1	1	1
E_5	0	1	0	0	1	0	0	0	0	0
E_6	0	1	0	0	1	1	1	1	1	1
E_7	0	1	0	0	1	0	1	0	0	0
E_8	0	1	0	0	1	0	1	1	1	1
E_9	0	1	0	0	1	0	1	1	1	1
E_{10}	0	1	0	0	1	0	1	0	1	1

Furthermore, revisions were made to SSIM with transitivity rules until a final reachability matrix was produced to determine the DP and D levels of the effective Mining Risk Education towards Agro-Eco-Tourism action plan (Table 17).

Table 17. Results of the aggregation of the final matrix revision on the action plan of the Mine Risk Education towards effective Agro-Eco-Tourism

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	D
E_1	1	1	1	1	1	1	1	1	1	1	10
E_2	0	1	0	0	0	0	0	0	0	0	1
E_3	1	1	1	1	1	1	1	1	1	1	10
E_4	1	1	1	1	1	1	1	1	1	1	10
E_5	0	1	0	0	1	0	0	0	0	0	2
E_6	0	1	0	0	1	1	1	1	1	1	7
E_7	0	1	0	0	1	0	1	0	0	0	3
E_8	0	1	0	0	1	0	1	1	1	1	6
E_9	0	1	0	0	1	0	1	1	1	1	6
E_{10}	0	1	0	0	1	0	1	0	1	1	5
DP	3	10	3	3	9	4	8	6	7	7	

The consistency of expert opinion by 99 percent (> 80 percent) means that the results of expert opinion are considered good.

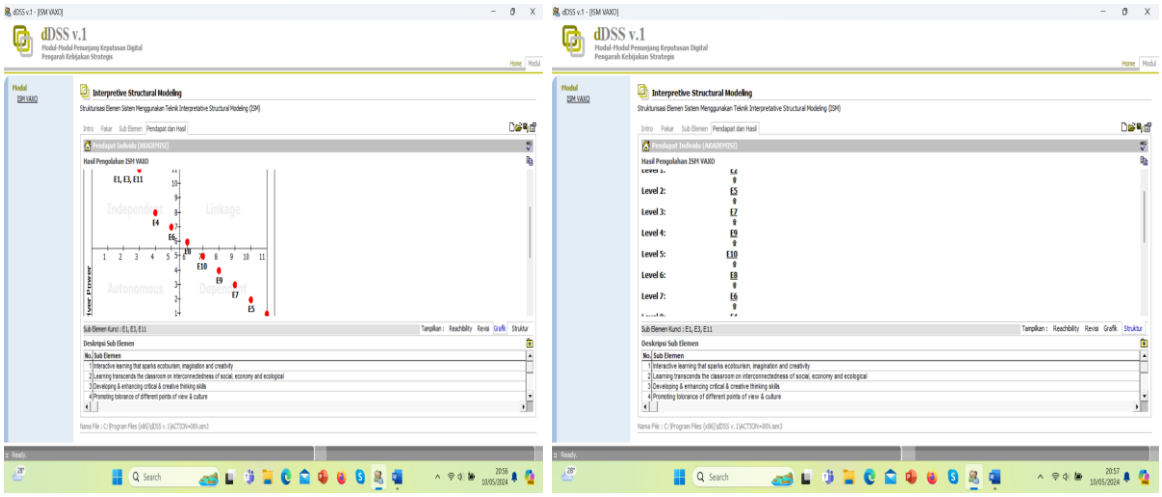

Figure 5. The relationship of *the Driver Power* and *Dependence* on the action plan of the Mining Risk Education towards Agro Eco-Tourism

The results of ISM processing has shown that *the 1st sub-element*, Interactive learning that sparks ecotourism, imagination & creativity (E1), *the 3rd sub-element*, Developing & enhancing critical & creative thingking skills (E3) and *the 11th sub-element*, Education to get a job that does't damage the environment [30]([31][32][33][34]. (E11) have the highest DP [11] and the lowest D (dependence) [3]; These sub-elements are called the key action plan (Figure 5). While *the 4th sub-element*, Promoting tolorance of different points of view & culture (E4) with DP [8] and D [4] and *the 6th sub-element*, Fosters sensitivity, appreciation & respect for the environment (E6) with DP [7] and D [5] are included in independent classification of action plan.

Figure 5 also has shown that *the 8th sub-element*, Strengthening community (E_8) with DP [3] and D [3] is included in the linkage classification.Furthermore, *the 10th sub-element*, Incorporating environment education into curriculum (E10) with DP [5,50] and D [7]; *the 9th sub-element*, Provides with support through grants & others resources (E9) with DP [4] and D [8], *the 7th sub-element*, Healthy lifestyle (E7) with DP [3] and D [9]; *the 5th sub-element*, Intergrates science & interdisciplinary learning (E5) with DP [2] and D [10] and also *the 2nd sub-element*, Learning transcends the classroom on interconnectedness of ecological, social & economy (E2) with DP [1] and D [11] are included in the dependent sector.

4.0 CONCLUSION AND RECOMMENDATION

The structural model of Mining Risk Education : Post-Mining Degradation Towards Agro-Eco-Tourism found three key goal elements, namely social change, focus on cultural anthropology towards sustainable development, Educate pedagogical becomes citizens who care environment, and Chemistry education becomes Environmental and Sustainability Education. The key changes of this model are Provide ideas to avoid danger and Encourage others to do the same, Intelligent mining and also Changes in safe behaviour. As a benchmark for goals on the model are The relevance of eco-tourism education and The availability of habitat (natural or artificial) of endemic flora or fauna. This model has main key constraint on the Lack of awareness and understanding of post minning risk, Interactive learning that sparks eco-tourism, Imagination and creativity, Developing and enhancing critical and creative thinking skills, and also Education to get a job that does not damage the environment. The key indicators are the relevance of agro-eco-tourism education; the availability of habitat (natural or artificial) of endemic flora or fauna. The key constrainte is the lack of awareness and understanding of the importance of changing post-mining to agro-eco-tourism. The key action plan are Interactive learning that sparks agro-eco-tourism; developing and enhancing critical and creative thinking skills; promoting tolerance of different points of view and culture.

REFERENCE

[1] S. Kivinen, ‘Sustainable post-mining land use: Are closed metal mines abandoned or re-used space?’, *Sustain.*, vol. 9, no. 10, 2017, doi: 10.3390/su9101705.
[2] T. Measham *et al.*, ‘Beyond closure: A literature review and research agenda for post-mining transitions’, *Resour. Policy*, vol. 90, 2024, doi: 10.1016/j.resourpol.2024.104859.
[3] U. Kaźmierczak, P. Strzałkowski, M. W. Lorenc, E. Szumska, A. A. P. Sánchez, and K. A. C. Baker, ‘Post-mining Remnants and Revitalization’, *Geoheritage*, vol. 11, no. 4, 2019, doi: 10.1007/s12371-019-00408-
[4] A. Bissex *et al.*, ‘Mine Risk Education’, pp. 1–86.
[5] S. Aminah, ‘Reswara : Jurnal Pengabdian Kepada Masyarakat’, no. 2020, 2022.
[6] H. Herdiansyah, M. U. Utami, and J. T. Haryanto, ‘Sustainability of post-mining land use and ecotourism’, vol. 6, no. 2, pp. 167–180, 2018.
[7] J. Herranen and M. Yavuzkaya, ‘Embedding Chemistry Education into Environmental and Sustainability Education : Development of a Didaktik Model Based on an Eco-Reflexive Approach’, 2021.
[8] Q. Yin, D. Wang, and Y. Wang, ‘Serial Mediation Model Linking Returnee Entrepreneurship Education and Green Returnee Entrepreneurial Behavior : An Analysis of Environmental Improvement’, 2023.
[9] N. M. Ardoin, ‘Selected Studies on Benefits of Environmental Education’, *J. Environ. Educ.*, 2017.
[10] eeWORKS, ‘Stanford analysis reveals wide array of benefits from environmental education’, *From Anecdotes to Evid. Demonstr. power Environ. Educ.*, 2017.
[11] I. Teacher-leaders, ‘Benefits of Environmental Education’, *Environ. Educ.*, 2003.
[12] J. van de Wetering, P. Leijten, J. Spitzer, and S. Thomaes, ‘Does environmental education benefit environmental outcomes in children and adolescents? A meta-analysis’, *Journal of Environmental Psychology*, vol. 81. 2022, doi: 10.1016/j.jenvp.2022.101782.
[13] N. Sprague, D. Berrigan, and C. C. Ekenga, ‘An Analysis of the Educational and Health-Related Benefits of Nature-Based Environmental Education in Low-Income Black and Hispanic Children’, *Heal. Equity*, vol. 4, no. 1, 2020, doi: 10.1089/heq.2019.0118.
[14] K. Bywater, ‘Investigating the benefits of participatory action research for environmental education’, *Policy Futur. Educ.*, vol. 12, no. 7, 2014, doi: 10.2304/pfie.2014.12.7.920.
[15] W. Hutcheson, P. Hoagland, and D. Jin, ‘Valuing environmental education as a cultural ecosystem service

at Hudson River Park', *Ecosyst. Serv.*, vol. 31, 2018, doi: 10.1016/j.ecoser.2018.03.005.
[16] 'Governance of safety and security programs the use of nuclear technology in Indonesia', vol. 6, no. 3, pp. 75–80, 2021, doi: 10.15406/mojes.2021.06.00218.
[17] I. Ismaniah, M. Dewi, D. Maharani, and T. Sri, 'Structural Model of Smart Integration of Green Open Space and Slaughterhouses', vol. 203, pp. 181–189, 2021.
[18] M. Endemi *et al.*, 'ELEMEN-ELEMEN KUNCI PENGELOLAAN EKOWISATA', vol. 1, no. April, pp. 35–45, 2022.
[19] V. April, S. K. Mulyaharja, M. D. D. Maharani, and L. Febrina, 'PEMANFAATAN TEKNOLOGI FOTHOVOLTAIC SURYA PADA KAWASAN AGRO-WISATA-HALAL', vol. 1, no. i, pp. 260–267, 2022.
[20] H. Bing-Yuan and K. Li-Xun, 'Mine land reclamation and eco-reconstruction in Shanxi province i: Mine land reclamation model', *Scientific World Journal*, vol. 2014. 2014, doi: 10.1155/2014/483862.
[21] G. Lasco and J. Mendoza, 'Deciphering a non-meal':, vol. 39, no. 2, pp. 194–215, doi: 10.14506/ca39.2.02.
[22] M. Rylnikova, D. Radchenko, and D. Klebanov, 'Intelligent Mining Engineering Systems in the Structure of Industry 4 . 0', vol. 01032, 2017, doi: 10.1051/e3sconf/20172101032.
[23] C. Zhensikbayeva, 'Endemic Flora and Fauna in Ecosystems : A Closer Look', vol. 12, pp. 2–3, 2024, doi: 10.37421/2332-2543.2024.12.526.
[24] D. J. Watchorn *et al.*, 'Artificial habitat structures for animal conservation : design and implementation , risks and opportunities', pp. 301–309, 2022, doi: 10.1002/fee.2470.
[25] M. Marwan, A. Heib, C. Franck, and H. Djizanne, 'Post-Mining Multi-Hazard Assessment for Sustainable Development', pp. 1–17, 2023.
[26] D. D. Tran *et al.*, 'Uncovering the lack of awareness of sand mining impacts on riverbank erosion among Mekong Delta residents : insights from a comprehensive survey', *Sci. Rep.*, pp. 1–13, 2023, doi: 10.1038/s41598-023-43114-w.
[27] I. O. P. C. Series and M. Science, 'Utilization of post mining land towards sustainable development', 2020, doi: 10.1088/1757-899X/830/3/032072.
[28] S. Zhang, X. Hua, G. Huang, X. Shi, and D. Li, 'What Influences Miners ' Safety Risk Perception ?', 2022.
[29] A. D. Sutrisno, Y. Chen, and I. W. K. Suryawan, 'Building a Community ' s Adaptive Capacity for Post-Mining Plans Based on Important Performance Analysis : Case Study from Indonesia', 2023.
[30] I. N. An, 'AND ITS IMPLICATION ON THE STUDENT ' S COMPETENCIES', vol. 38, no. 3, pp. 552–564, 2019, doi: 10.21831/cp.v38i3.23154.
[31] A. Husin and A. Saleh, 'Opportunities for the School System to Instill Environmental Values', pp. 1649–1656, 2019, doi: 10.4236/jep.2019.1012098.
[32] B. Marinette, 'THE IMPACT OF SCHOOL ENVIRONMENT ON TEACHERS ' JOB SATISFACTION', no. June, 2021, doi: 10.46827/ejes.v8i7.3799.
[33] D. Demirovi and N. Vuksanovi, 'Significance of the Work Environment and Personal Resources for Employees ' Well-Being at Work in the Hospitality Sector', 2022.
[34] M. Jaoul-grammare, A. Stenger, and A. Stenger, 'What role does education play in environmental concerns?', vol. 417, no. 1, 2022, doi: 10.57706/CEREQBREF-0417.